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Responsible innovation scholarship: normative, empirical, theoretical, and engaged

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Introduction

Ten years ago, after nearly five years of planning, the *Journal of Responsible Innovation* was launched in 2014 with the intention to 'manifest and broaden' (Guston et al. 2014) an emerging international network of scholars and practitioners interested in the study of responsible innovation, broadly understood.[1] At the time, the editors envisioned the scholarship in this area to encompass a variety of normative aspirations, mobilizing concepts, intellectual debates, and wicked challenges. Since then, alongside rapid technological developments, considerable and ongoing global challenges, as well as the churn of policy discourses, we have witnessed the tremendous growth of a rich and diverse body of scholarship focused on illuminating and informing 'the normative governance, practice, and assessment of knowledge-based innovation' (*JRI* Aims and Scope). Thanks to an international, interdisciplinary,[2] and vibrant community of authors, readers, reviewers, editorial board members, guest editors, and editorial assistants, we have been honored to help steward *JRI* as a platform for this highly engaged and broadly sourced scholarship.

As *JRI* wraps up its 10th year, we mark this moment by offering an editorial review of slightly more than 300 articles[3] that the journal has published during this time. We propose that during this time, responsible innovation scholarship has developed into a diversely sourced, intricately conversant, and richly evolving field of study. As one sign of this, we find that *JRI* authors have collectively formulated, investigated, and debated a plurality of aspirational visions, normative programs, and operational

frameworks. Yet, despite this diversity of commitments and orientations, we also find multiple critical, coherent, and evolving themes through which *JRI* articles are conversant with and responsive to both one another and a rapidly changing technological, political, and global context. Perhaps most interesting, we find distinctly configured and diversely mobilized modes of approach, or *styles*, of the scholarship itself.

Accordingly, rather than seeking to provide a comprehensive and nuanced discussion of the content developed by *JRI* authors as a scholarly literature review might undertake, this editorial review instead provides a map of the multiple divergent and convergent scholarly approaches to studying responsible innovation and the intricate and flexible employment *JRI* authors have made of these resources. While other reviews of responsible innovation have analyzed its policy origins and rationales (de Saille 2015), definitional and conceptual themes (Burget, Bardone, and Pedaste 2017), roots in nanotechnology (Rip 2018), sociological characteristics (Brundage and Guston 2019), divergent intellectual and policy agendas (Owen and Pansera 2019), theoretical and practical development (Schuijff and Dijkstra 2020), alternative histories (Shanley 2021), academic organization and knowledge base (Wiarda et al. 2021), unfinished journey (Owen, von Schomberg, and Macnaghten 2021), the emergence of academic-policy discourse coalitions (Randles, Tancoigne, and Joly 2022), and thematic pathways to integrate scholarly streams (Barlatier et al. 2024), this review focuses primarily on elucidating the distinct yet blended scholarly *styles* of its – largely Mode 2 (Nowotny, Scott, and Gibbons 2003) forms of – knowledge production. Accordingly, we do not provide sustained analysis of the issues and debates; theories and methods; or disciplinary, geographical, or epistemic cultural sources employed in the journal's articles. Instead, we highlight the various spaces for scholarly inquiry and interaction that *JRI* has cultivated to establish a platform for understanding, observing, debating, and probing the 'normative governance, practice, and assessment of knowledge-based innovation' (*JRI* Aims and Scope) as a key and sustaining goal for the journal.

A plurality of constructs

Before turning to the scholarly *styles* and some of the topical themes they investigate, we first consider one measure of their diverse interests and orientations. As the cognates, constructs, programs, and precedents listed below suggest, responsible innovation remains an underdetermined, contested, and encompassing concept that is subject to considerable interpretive flexibility. Over the past decade, these and many others programmatic frameworks and agendas have been articulated, interrogated, circulated, and employed by *JRI* authors. Some of the frameworks, conceptions, tools, and approaches, listed here have been influential and widely taken up, while others are emerging or being newly repurposed. As evident from the many cognates – and from *JRI*'s Aims and Scope as well as the journal's history of editorials (Guston et al. 2014; Guston 2014a, 2014b, 2015a, 2015b, 2015c; Fisher 2016a, 2016b, 2016c, 2017a, 2017b, 2017c, 2018a, 2018b, 2019b, 2019c, 2019d, 2020a, 2020b, 2020c, 2021a, 2021b, 2021c, 2022a, 2022b)[4] – *JRI*'s ecumenical approach to responsible innovation does not equate that term with any particular construct, seeing it rather as capable of encompassing many, if not most of them. We believe it is vital to cultivate such pluralistic space for responsible innovation, even while we remain committed to fostering a platform that encourages rigorous investigation and vigorous

debate about the comparative merits of any given concept or proposition. The following cognates, constructs, and approaches to responsible innovation represent a sample of those which have appeared in *JRI* publications since 2014:[5]

- Anticipatory Governance
- Anticipation, Inclusion, Reflexivity, Responsiveness (AIRR)
- Anticipation, Reflection, Engagement, Action (AREA)
- Appropriate Technology
- Argumentative Technology Assessment
- Care Ethics
- Citizen Science
- Civic Ethics
- Civic Responsibility
- Constructive Technology Assessment (CTA)
- Corporate Citizenship
- Corporate Social Responsibility (CSR)
- De facto Responsible Innovation
- Deliberative Democracy
- Duty of Care
- Engineering Ethics
- Ethical, Legal, and Societal Implications/Aspects (ELSI/ELSA)
- Ethical Technology Assessment
- Ethics by Design
- Fiduciary Responsibility
- Grand Challenges
- Health Technology Assessment
- Hermeneutic Technology Assessment
- Interactive Technology Assessment
- Living Labs
- Responsible Management of Innovation
- Mission-oriented Innovation
- Norm-Critical Innovation
- Normative Business Model
- Open Science
- Open Innovation
- Parliamentary Technology Assessment
- Participatory Design
- Participatory Technology Assessment
- Post-ELSI
- Precautionary Principle
- Privacy by Design
- Procedural Ethics
- Public Engagement
- Public Interest Technology (PIT)
- Real-Time Technology Assessment
- Reflexive Governance

- Research Ethics
- Responsible Design
- Responsibility by Design
- Responsible Innovation (RI)
- Responsible Innovation in Industry
- Responsible Research and Innovation (RRI)
- Responsive Science
- RRI Keys
- Self-Regulating Organization
- Slow Innovation
- Social Labs
- Social License to Operate
- Social Life Cycle Assessment
- Societal Engagement
- Sociotechnical Design
- Socio-Technical Integration Research (STIR)
- Sustainability
- Sustainable Development
- Technology Assessment (TA)
- Traditional Ecological Knowledge (TEK)
- Value Sensitive Design (VSD)
- Values Absorption
- Vision Assessment
- Value Change

Scholarly styles

Another indication of the rich offerings to be found more broadly within this academic field of endeavor is how robustly *JRI* authors can be seen to have employed distinct – and expansive – ways of knowing, modes of inquiry, and approaches to social scientific and humanistic knowledge production, both separately from and in combination with one another. Through inductive and deductive coding[6] of *JRI* articles published between 2014 and 2023, we identify a set of four analytically distinct yet observably entwined scholarly *styles* – which we term here *Articulation*, *Interpretation*, *Assessment*, and *Intervention*.

Scholarly Approaches to Responsible Innovation	
Articulation	*Theoretical and conceptual inquiry and argumentation*
Interpretation	*Empirical observation and analysis*
Assessment	*Normative evaluation, appraisal, and critique*
Intervention	*Collaborative, deliberative, and experimental engagement*

As we discuss later (Tables 1 and 2, Figure 1), most *JRI* articles employ a combination of these *styles* rather than one single *style*. Hence most of the articles that appear as examples in the following four sections on the scholarly *styles* appear only once, even though they could have appeared multiple times. Please note that, to keep the length
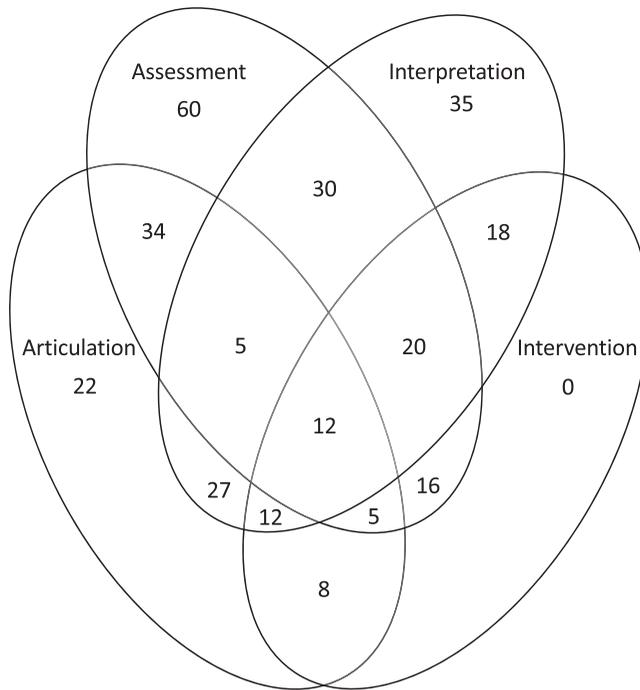
Figure 1. Breakdown of the scholarly styles and their combinations within *JRI* articles.

of this review manageable, we employ in-text citations sparingly: although we could have listed numerous more articles under each *style*, theme, and (in most cases) sub-theme, we chose instead to provide only a few suggestive illustrations in most cases and to instead emphasize the overall contours of this rich and intricate body of scholarship. Furthermore, we present in-text citations in chronological rather than alphabetical order to provide a sense of continuity in the scholarly discussions that have taken place over the last 10 years in *JRI*.[7]

Articulation

JRI articles that we associate with this scholarly *style* tend to engage in various types of theoretical inquiry, including philosophical (Nordmann 2014), phenomenological (Kiran, Oudshoorn, and Verbeek 2015), sociological (Dickel and Schrape 2017), post-structuralist (Torgersen and Fuchs 2017), institutional (Kuzma et al. 2018), moral psychological (Umbrello 2018), hermeneutic (Grunwald 2020), conceptual (Jacko 2020), political economic (Papaioannou 2020), and organizational and business management (Garst et al. 2022), among others. More broadly, articles pertaining to this *style* engage in the development of frameworks, concepts, models, methods, thought experiments, scenarios, and other theoretical, conceptual, and analytical resources (e.g., Ganzevles, van Est, and Nentwich 2014; Li et al. 2015; Demers-Payette, Lehoux, and Daudelin 2016; Daimer et al. 2021; Stahl et al. 2021; Popa and Blok 2022; Ryan et al. 2023). Here, we highlight a handful of topical themes that can be discerned within this *style* and that have been features of the journal from its early beginnings.

Normative foundations

A number of *JRI* authors formulate, extend, compare, criticize, or otherwise develop theoretical, conceptual, and analytical foundations meant to illuminate, approach, or advance responsible innovation. Foundations may be prescriptive or descriptive, substantive or procedural, and may take the form of principles, visions, virtues, injunctions, conditions, and other manifestations.

For example, Nordmann (2014) considers the normative meanings and prospective implications of the injunction to 'consider the considerations' during technology development; Blok (2014) develops a concept of stakeholder dialogue and explores its implications for responsiveness; Grunwald (2017) argues that the assignment of meaning in emerging technologies is itself an object of responsibility; Ribeiro et al. (2018) highlight societal alignment as a governance aspiration; and Fuenfschilling, Paxling, and Vico (2022) make a case for norm-critical innovation as a way to foster responsible innovation. Others analyze articulations, whether for the sake of understanding their cultural dimensions (e.g., Glerup and Horst 2014), comparing their normative strategies (e.g., Pellé 2016), refining and extending their normative principles (e.g., Foley, Bernstein, and Wiek 2016), identifying their conceptual similarities (e.g., Conley 2020), synthesizing them (e.g., Fraaije and Flipse 2019), assessing their historical development (e.g., Shanley 2021), or extracting recommendations (e.g., Ten Holter 2022).

More critical theoretical engagement may expose a lack of attention to the political dimensions of deliberative frameworks (e.g., van Oudheusden 2014), identify dilemmas posed by liberal democratic assumptions in conceptions of responsible innovation (e.g., Wong 2016), insist on contextual differences across sites and locations of innovation (e.g., Mertens 2018), or reveal key tensions in applying deliberative ideals within specific settings (e.g., Brand and Blok 2019). Such work may also reconceptualize responsible innovation from Global South (e.g., Wakunuma et al. 2021), Indigenous (Macdonald et al. 2021), and other often overlooked perspectives. Meanwhile, articulation of context-specific foundations includes those tailored to the circular economy (Pansera, Genovese, and Ripa 2021), urban technologies (Stone 2021), multispecies relations (Szymanski, Smith, and Calvert 2021), medical and health technologies (e.g., Naughton, Dopson, and Iakovleva 2023), and smart city development (Heezen et al. 2023), among others.

Politics and governance

A second *Articulation* theme concerns the theory and philosophy of the politics, policy, and governance of research and innovation, an area that manifests in a diverse collection of intersecting topics and approaches. For instance, Holbrook and Briggle (2014) argue for limiting the role of principles in science and technology policymaking to promote timely action, while Schroeder and Ladikas (2015) would seek to realize principles such as responsibility and justice in research funding decisions. Åm (2019) develops a meta-governance focus that would create conditions for responsible innovation practices, Reijers (2020) elucidates relations between virtue and governance, Sauer and Bonelli (2020) propose collective improvisation as a means to move from 'ungovernable

to governable' serendipity in innovation, and von Schomberg and Blok (2023) articulate a political concept of responsible innovation that aims to accommodate private and public interests alike. Relations between justice and innovation are a shared focus across numerous contexts, including those of non-economic dimensions of innovation (Ziegler 2015), the phenomenology of techno-politics (Bergen 2017), resource allocation (Gildenhuys 2020), Traditional Ecological Knowledge (Ludwig and Macnaghten 2020), anti-Black surveillance (Williams 2020), and cases of epistemic injustice (Valkenburg et al. 2020, Koch 2020; Ottinger 2023). Similarly, authors who study the political economy of responsible innovation approach it from diverse evolutionary (Papaioannou 2020), planning (Thorpe 2020), no growth (Albertson et al. 2021), and neoclassical (Lukovics et al. 2023) perspectives.

Ethics and values

Discussions and debates about ethics and values make up another thematic area among articles in this *style*. Taebi et al. (2014) conceptualize responsible innovation as 'the adequate and timely inclusion of public values relevant to technological development'; Kiran, Oudshoorn, and Verbeek (2015) formulate principles for internalizing ethical considerations in technology development processes; and Thompson (2018) offers a framework for organizing ethics research that goes beyond research ethics and risk assessment to include fiduciary responsibilities, democratization, epistemologically mediated social power relations, and ethics integration in research and development. Reber (2018) considers problems raised by 'broadening ethics to a more political understanding of responsibility or simply to more inclusive participation.' Boenink and Kudina (2020) argue that approaches that treat values as 'relatively stable entities, directly available for reflection' fail to grasp 'the hermeneutic work required to identify values' and thus fall into an 'entity trap.' Politi and Grinbaum (2020) characterize members of the scientific community based on their participation in the collective activity of ethical reflection, drawing out implications for the institutionalization of ethics in science.

Reflexive heuristics

The process of articulation can itself be the subject of conceptual and theoretical analysis and critique. Zimmer-Merkle and Fleischer (2017) call for a more careful and deliberate employment of 'historical knowledge' in both TA and RRI; Umbrello (2018) assesses the value of moral intuitions for informing decisions aimed at responsible innovation; Steinert and Roeser (2020), noting the intimate relations between values and emotions, encourage scholars who engage in foresight exercises to consider the potential effects of how they frame their interventions; and van den Hoven (2022), responding to Shanley et al.'s critique of RRI (2022), argues that

> Any framework that aims at being both normatively critical and practically relevant will have to support human beings in bringing their ethical ideals, moral principles and values to bear effectively upon the shaping of our world, and inserting them at a place and time they can make a difference and in a form that increases the likelihood that they will have impact.

Finally, Ottinger (2023), considering epistemic resource invention, makes a case for responsible epistemic innovation and Urueña (2023), in proposing an approach for

'enacting anticipatory heuristics,' provides a fitting application of Ockham's Razor, urging scholars who develop and apply future-oriented governance frameworks to 'minimise the uncritical reification of futures.'

Interpretation

A second scholarly *style* consists of empirical inquiry into the 'normative governance, practice, and assessment of knowledge-based innovation' (*JRI* Aims and Scope). *Interpretation* thus brings us down from abstract conceptions and frameworks to specific contexts, cases, applications, and observable patterns and phenomena.[8] The range of topical interests evident in this *style* includes actors, institutions, discourses, norms, practices, and various other objects of study. Observations are refracted through numerous interpretive lenses including but not limited to anthropological, historical, organizational, phenomenological, and sociological approaches. *Interpretation* also draws on a wide variety of qualitative methods, including but not limited to interviews, case studies, focus groups, surveys, ethnographies, participant-observation, and collaborative and deliberative interactions and experiments (see *Intervention*), as well as a handful of quantitative and mixed methods. Among the numerous scholarly conversations and subject areas that can be found here, we highlight four prominent contextual themes.

Local and global

Over the past decade, *JRI* authors have conducted empirical studies within and across an expanding range of local, global, national, and other place-based settings. Alongside studies situated within and across Europe (e.g., Thorstensen and Forsberg 2016; Delvenne and Rosskamp 2021; Psarikidou 2023) and North America (e.g., Bronson 2015; Dotson 2019; Woodson, Telendii, and Tolliver 2020), *JRI* authors explore tensions, paradoxes, and possibilities of debating and pursuing responsible innovation within various African (e.g., Biddle 2017; Hartley et al. 2019; Ledingham et al. 2023), Australian (e.g., Ashworth et al. 2019; Lacey, Coates, and Herington 2020; Fielke et al. 2023), Asian (e.g., Gao, Liao, and Zhao 2019; Ko, Yoon, and Kim 2020; Wang and Long 2023), and South American (e.g., Macnaghten 2016; de Campos et al. 2017; Macnaghten and Guivant 2020) settings. For instance, debates over the extension and uptake of responsible innovation at a global scale have produced studies that engage with the 'transduction' of articulated frameworks, principles, and conceptions across spatial borders (Doezema et al. 2019).

Within this scholarly *style*, one consistent focus has been on the importance of engaging with local, traditional, and Indigenous forms of knowledge. For instance, Groves et al. (2016) explore how individuals make sense of their everyday use of energy technologies, finding that 'mundane engagements with technologies may be a resource for re-imagining smartness in the context of collective engagement, in families and communities, with energy infrastructure.' Additionally, Ludwig and Macnaghten (2020) highlight connections among shifting meanings of innovation, governance frameworks for responsible innovation, and the role of TEK in the self-determination of traditional communities; Macdonald et al. (2021) find that protocols for indigenous-led innovation in Kakadu National Park in Australia that they helped co-develop

provide a way for Indigenous cultural responsibilities for knowledge sharing and steward-
ship of country to guide and authorise the co-design and application of technological inno-
vations, which are increasingly being used to produce new knowledge to adaptively co-
manage Indigenous people's lands and seas;

and Foley, Sylvain, and Foster (2022) study a collaborative approach to networked com-
puting in New York City's Harlem neighborhood as an alternative and highly localized
response to the societal challenge known as the digital divide.

A related trend takes up the global, grand, and social 'challenges' narrative proposed
by a number of governments to drive and direct innovation policy (e.g., van der Molen
et al. 2019; Välikangas 2022). Thus, Kaltenbrunner (2020) examines the mechanisms
through which German university scientists integrate mission-oriented funding
program objectives into their research agendas, highlighting tensions 'between the nor-
mative goals of grand challenges and the practical uncertainty that reliance on such
funding creates for recipients'; and Ludwig et al. (2022) critically examine how
typical responses to global challenges are addressed by governance actors, arguing
that appeals to global challenges can give rise to a 'solution strategy' that can legitimise
and reinforce dominant responses.

Institutions and organizations

Empirical studies also encompass institutional and organizational structural norms,
mechanisms, organizing principles, arrangements, and the like. For example, *JRI*
authors analyze the conception, development, and implementation of responsible inno-
vation within various settings, including governmental (Anzaldo Montoya and Chauvet
2016; Reyes-Galindo, Monteiro, and Macnaghten 2019), private sector (Demers-Payette,
Lehoux, and Daudelin 2016; Garst et al. 2022; Ivanova et al. 2023), university (Holloway
and Herder 2019; Ryan, Mejlgaard, and Degn 2021; Dabars and Dwyer 2022; Välikangas
2022; Fuchs, Bombaerts, and Reymen 2023), research and infrastructural (Aicardi, Rein-
sborough, and Rose 2018; Pansera et al. 2020; Stahl et al. 2021), civil society (Ahrweiler
et al. 2019; Campos and Marín-González 2023; Felt et al. 2023), and professional and
organizational (Arnaldi and Neresini 2019) contexts.

Within governmental settings, for instance, Owen (2014) chronicles the evolution of
a responsible innovation framework in the UK's EPSRC Research Council; de Saille
(2015) explores the processes by which RRI was incorporated as a policy framework
into the European research policy apparatus and resulting tensions; Rip (2016) charac-
terizes the European Commission's embrace of RRI as a case of the emperor's new
clothes; Egeland, Forsberg, and Maximova-Mentzoni (2019) interpret the conceptual-
ization and implementation of responsible innovation within the Research Council of
Norway from a learning perspective; Owen, von Schomberg, and Macnaghten (2021)
provide a 10 year retrospective on the UK's RI framework and RRI at the European
Commission; and Tabarés et al. (2022) find that limited implementation of RRI
within Europe 'is the result of conflicts with existing values, science cultures, economic
objectives, restricted resources for its implementation and a lack of clarification around
what RRI means.'

Examples of studies within the private sector include Asante, Owen, and Williamson
(2014), who find that modest conceptions of and mechanisms for responsible innovation

within a global asset management company nevertheless offer 'considerable scope … for systematic embedding of more broadly framed, emerging concepts of responsible innovation'; Hemphill (2019), who proposes the self-regulatory organization as an approach to responsible innovation in lieu of public regulation; Steen and Nauta (2020), who assess advantages and disadvantages of social engagement for Research and Technology Organizations (RTOs); and Li, Owen, and Shaw (2023), who find from a study of companies within China's Hunan province that 'extant framings of innovation and responsibility are underpinned by a mixture of logics and institutional entrenchments that are heavily influenced by the norms, policies, and ideology of the State,' and which in turn shape perceptions of responsible innovation.

Practices and performances

Practices, commitments, and choices in the performance and governance of research and innovation make up another contextual theme. This object of empirical inquiry may be conceptualized from cultural or institutional, formal or informal, ethical or psychological standpoints, among others. Articles in this area often focus on scientific, technical, entrepreneurial, and policy actors as agents or participants within larger socio-political systems.

For instance, Rosenlund, Notini, and Bravo (2017) investigate the effects of reflection on societal relevance on the research choices of Swedish environmental scientists; Lösch, Heil, and Schneider (2017) analyze the processes of producing, distributing, and denying particular responsibilities between actors in future visioning around innovation. Åm (2019) finds that scientists participating in a large Norwegian funding program tend to accommodate rather than enact mandated forms of responsible innovation, likely because such mandates seem to add to researchers' practical problems rather than helping address preexisting ones; Lubberink et al. (2019) studies the ways in which social entrepreneurs from Europe and North America integrate values into their responsible innovations; analyzing a case study of 12 public engagement exercises across Europe, Repo and Matschoss (2019) show that 'experts may easily take over the process of involvement and change the outcomes in quite distinct directions … while still claiming to draw legitimacy from citizens'; based on her study of a transdisciplinary research project in Austria, Schikowitz (2020) argues that transformation of research enterprises for societal relevance will require development of ways to reconcile policy, practical, and scientific relevance 'on the project level and also within individual careers.' Regan (2021) 'explores the readiness of publicly funded researchers in Ireland to engage in RRI activities in digital agriculture'; and, as a final example, Silva, Lehoux, and Sabio (2023) empirically examine the principles and criteria social finance investors in Canada and Brazil use in selecting potential investees and thus in supporting responsible innovation.

Views and discourses

Empirical studies also analyze perceptions, expectations, views, discourses, attitudes, and beliefs of relevant actors, stakeholders, and social groups regarding the normative governance and practices of research and innovation. These may, for instance, examine

views on responsibility among scientific researchers (Frankel 2015; Sand and Jongsma 2020; Moon and Kahlor 2022); experts, administrators, and policy makers (Li et al. 2015; Carrier and Gartzlaff 2020; Ruder and Kandlikar 2023); business professionals and entrepreneurs (Li, Owen, and Shaw 2023); citizens, consumers, and civil society groups (Capurro et al. 2015; Akin et al. 2019; Forsberg et al. 2023), as well as others involved or implicated in research and innovation undertakings.

By way of example, Glerup, Davies, and Horst (2017) investigate how scientists in Denmark, the UK, and the US perceive (and also practice) responsibility and find that 'though the scientists in this study mostly viewed policy discourses such as Responsible Research and Innovation (RRI) as irrelevant to them, they articulated and practiced a range of 'bottom-up' responsibilities.' The authors conclude that scholarship on responsible innovation should 'work to develop a shared language of responsibility with scientists' and 'more actively address the political context of contemporary scientific research.' Similarly, in a study of Canadian professionals who develop and commercialize health innovations, Rivard and Lehoux (2020) find that, while 'innovators generally agree on the desirability of several responsibility principles,' they also 'identify feasibility issues that call for attention if RRI is to be meaningfully implemented in the health field.' Drawing on a survey of Australian scientists, Lacey, Coates, and Herington (2020) conclude that responsibility for a cultural transition towards responsible innovation – understood in their case as science that is more open and transparent – lies not only with researchers but with research funders and other agencies.

Assessment

A third discernable *style* of scholarship focuses on normative appraisal, evaluation, and critique. Within *Assessment*, we call attention to three different themes. One is made up of articles that engage in future-oriented appraisal of ongoing and emerging programs of research and innovation. Another employs normative frameworks and critical commitments to evaluate substantive (e.g., Pellé 2016), procedural (e.g., Hartley et al. 2019), and discursive (e.g., Nelson, Selin, and Scott 2021) outcomes of institutional commitments and policy programs. A third theme develops and advances scholarly standpoints and opinions (Gerber et al. 2020).

Ethics and futures appraisal

This theme is home to multiple approaches and includes prospective appraisals of the normative implications of new and emerging science and technologies and their governance by stakeholders (e.g., Kuzma et al. 2018; Cohen, Stilgoe, and Cavoli 2018), economic and policy experts (e.g., Mitchell, Brown, and McRoberts 2018; Ramos et al. 2018), and the responsible innovation scholarly community itself (e.g., Robinson, Simone, and Mazzonetto 2021; Ledingham et al. 2023).

Whether guided by ethical frameworks, foresight methods, or stakeholder values, such articles may, assess social and ethical aspects of exoskeletons in a disabilities context (Sadowski 2014); assess the preparedness of governmental institutions to regulate insects and animals with gene drives (Meghani and Kuzma 2018); elucidate stakeholder typologies of concern regarding self-driving cars (Cohen, Stilgoe, and Cavoli 2018);

articulate an interdisciplinary research agenda to safeguard public values given an 'institutional void' in the governance of crowd-based innovations (Cuppen, Klievink, and Doorn 2019); survey experts to anticipate risks and ethical dilemmas associated with the prospect of biotechnology-enabled de-extinction (Valdez et al. 2019); assess wearable, non-invasive, brain-monitoring technologies from the standpoint of human experience (Risnes et al. 2023); and identify normative and epistemic implications of machine learning classification models for combating online misinformation (Hernández et al. 2023), to describe just a few examples.

The framing and interpretation of public appraisal itself has been the subject of considerable debate. For instance, Bechtold, Capari, and Gudowsky (2017) describe significantly divergent results between three different TA efforts involving experts, stakeholders, and laypersons, suggesting that greater effort may be needed to identify and integrate different visions of technological change; Hayes et al. (2018) cite 'potentially adverse ecological outcomes associated with the release of gene-drive modified organisms' and advocate for methods to assess ecological dimensions of the release of these organisms; and Delborne, Kokotovich, and Lunshof (2020) underline 'the problematic nature of one paradigm being drawn upon to conceptualize … public engagement for synthetic biology: social license to operate (SLO),' particularly as SLO originates in the extractive industries where it signifies a one-sided orientation towards securing acceptance in ways contrary to the reciprocal ethos of responsible innovation. By contrast, Russell et al. (2022) find that the appeal of SLO in synthetic biology may well 'co-exist with a willingness to countenance modifying the design of technologies based on wider input.'

Outcomes evaluation

These articles also conduct evaluative assessments of ongoing or concluded policy, program, and project-level outcomes, trends, and developments, often retrospectively but with an eye to the future and from substantive, procedural, discursive, and other standpoints.

Articles in this theme tend to combine *Interpretation* and *Assessment* and may evaluate funding programs that emphasize aspects of responsible innovation (Owen 2014; Ashworth et al. 2019; Ladikas et al. 2019; Lacey, Coates, and Herington 2020; Owen, von Schomberg, and Macnaghten 2021; Tabarés et al. 2022; Ryan and Blok 2023); large research and emerging technology programs such as nanotechnology (Anzaldo Montoya and Chauvet 2016; Ghiasi, Harsh, and Schiffauerova 2020), synthetic biology (Evans 2015; Wolfe 2015), gene drives (de Campos et al. 2017; Nelson, Selin, and Scott 2021), brain science (Stahl et al. 2021; Ulnicane, Mahfoud, and Salles 2023), and the circular economy (Pansera, Genovese, and Ripa 2021); government responses such as to Zika (Monteiro, Shelley-Egan, and Dratwa 2017) and Covid outbreaks (Smits et al. 2022); and corporate practices such as gamification in the workplace (Ruggiu et al. 2022); as well as individual projects and services (De Hoop, Pols, and Romijn 2016; Groves 2017). For instance, Anzaldo Montoya and Chauvet (2016) find that Mexican nanotechnology policy is 'doubly subordinate' to decisions both in the international arena and in the US, limiting opportunity for a governance distinctively tailored to the Mexican context; and Gardezi et al. (2022) find that agricultural decision support

systems (DSS) 'transform agricultural knowledge production, reconfigure labor arrangements and unevenly distribute benefits and burdens among farmers' in Vermont and South Dakota. They recommend that agritech developers 'implement inclusive and deliberative processes when redesigning DSSs to engender ethical, equitable and sustainable improvements to food production systems.'

Scholarly assessment

By far the largest number of articles that participate in *Assessment* are those that advance scholarly perspectives and opinions. Many of these, although certainly not all, take the form of *JRI* Perspectives: short peer-reviewed articles that provide critical commentaries, provocative opinions, or research communications.

Of the many forms of scholarly assessment that appear in *JRI*, a prominent one is the critical and comparative critique of responsible innovation frameworks and foundations (*Articulation*). Thus, cautioning against the association of Corporate Social Responsibility (CSR) with responsible innovation, Hemphill (2016) proposes the alternative framework of corporate citizenship, since it 'incorporates the concept of social responsibility into the organizational structure of the firm and is reflective of the ISO 26000 voluntary international standard on social responsibility.' While noting the 'considerable overlap' of RRI 'with the aims, philosophies and practices' of TA, van Lente, Swierstra, and Joly (2017) nevertheless explore an interpretation of 'RRI as a critique of TA' due to the former's more explicit approach to both normativity and stakeholders in the governance and assessment of technology. In response, Delvenne (2017) suggests that 'RRI could instead lead to a travesty of TA,' since it may threaten 'the vitality and the uniqueness of TA institutions in the long-term.' After identifying key challenges that limit the practice and uptake of 'more inclusive and responsible forms of research and innovation,' Ribeiro et al. (2018) propose a shift from one central conceptual underpinning of the responsible governance of research and innovation – Collingridge's dilemma of social control of technology – to the 'dilemma of societal alignment,' arguing that such a shift would better frame 'difficulties in democratizing science, technology, and innovation, addressing divergent stakeholder perspectives, and ensuring a closer correspondence between their benefits and the needs of diverse publics.'

Scholarly assessments that are more closely informed by empirical material (*Interpretation*) include van Oudheusden (2014), who studies the operationalization of responsible innovation on an EU policy level and in a particular Flemish TA context, and who critiques elision of the politics of responsible innovation practices themselves in these discourses. Kuzma and Roberts (2018), responding to Ribeiro et al. (2018), provide a catalogue of some of the central barriers to societal alignment they have found, organized according to temporal stages and organizational levels of innovation. They urge the responsible innovation scholarly community to increase its 'understanding of innovators' biases and the organizational and political limitations that are very likely to persist'. Van de Poel et al. (2020) distill lessons learned from a varied and robust set of interventions across numerous industrial sites, while Politi and Grinbaum (2020) argue for a targeted approach to the institutionalization of ethics within science on the basis of their finding that ethical labor is unevenly distributed across 'different kinds of scientists within the scientific community.'

Still others critically engage with specific scholarly and/or practitioner debates. Thus, Koch (2020) calls for a more integrated and robust conversation among those interested in stakeholder inclusion, epistemic justice, and the empowerment of marginalized scholars that focuses on 'a collective duty to care for diversity and address inequalities within the scientific field.' Williams (2020) brings a focus on racial injustice to bear on debates about exnovation (cf. Ziegler 2015; De Hoop, Pols, and Romijn 2016), arguing that 'systems like facial recognition, predictive policing, and biometrics are predicated on myriad human prejudicial biases and assumptions which must be named and interrogated prior to any innovation.' Monteleone (2020), echoing Nielsen and Boenink's (2020) 'subtle voices,' argues for the inclusion of 'forgotten publics' through changing passive patient roles into active and meaningful engagement, in particular for underrepresented (in this case, disabled) groups for inclusion in responsible healthcare innovation. Steen (2021) supplements the debate about temporalities of innovation – cf. Ganzevles, van Est, and Nentwich (2014), Woodhouse (2016), Dickel and Schrape (2017), Briggle (2019) – with a perspective on individual practice and experience, encouraging innovators to make time for 'uneasy questions, vulnerable experiences, awkward moments and uncertainty.' As van Oudheusden and Shelley-Egan (2021) characterize this position, 'if innovation is to contribute positively to our world, it must be slowed down, following the unruly tempos of ecological and social processes.'

Intervention

A fourth discernable *style* involves scholarly efforts to inflect, broaden, cultivate, co-create, or otherwise influence responsible innovation in specific sites and settings, typically with the author playing a critical role in designing or deploying theoretically-, empirically-, or methodologically-informed interactions. Unlike *Articulation*, *Interpretation*, and *Assessment*, the articles in this *style* always appear in combination with one or more of the other three. Intervention-oriented research varies across science and innovation actors, sites, and contexts and may be geared toward promoting democratic values through public engagement, collaboratively integrating societal considerations into university research or industrial innovation practices, broadening policy frameworks and institutional guidelines, or the use of critical pedagogies. A common focus across many of these studies is on understanding the roles that informal competences for self-organization and distributed knowledge production may play in informing the normative practice and governance of knowledge-based innovation. We highlight three agential themes, focusing on interventions among different types of actor groups.

Public and stakeholder engagement

Engagements focused on understanding inclusion, participation, and deliberation of various publics and stakeholders and their involvement in research and innovation make up one theme within *Intervention*. Many, but not all, of these articles overlap with the *Assessment* of various forms of emerging science and technology, from synthetic biology (Brian 2015) and assistive technology (Bechtold, Fuchs, and Gudowsky 2017) to biofuels (Groves, Sankar, and Thomas 2018), food and nutrition (Roßmann 2021), gene drives (Russell et al. 2022), and others. Such engagements take numerous forms,

including public and citizen consultations (Chalmers et al. 2014; Ketzer et al. 2020), deliberative mini publics (Capurro et al. 2015), scenario development workshops (Schulz-Schaeffer and Meister 2017), deliberative workshops (Groves, Sankar, and Thomas 2018), stakeholder workshops (Cohen, Stilgoe, and Cavoli 2018), public deliberation experiments (Macnaghten and Guivant 2020), participatory design (Ten Holter 2022), and co-creation workshops (Jansma, Dijkstra, and de Jong 2022), among others.

Macnaghten et al. (2014) elucidate relevant tensions, paradoxes, and opportunities that emerged from a workshop they conduct among researchers from Brazil and the UK on the governance of socially controversial technologies. Di Giulio et al. (2016) explore how stakeholder contributions may be included meaningfully in research and governance processes, especially in the face of challenges such as incompatible epistemologies. Schulz-Schaeffer and Meister (2017) argue that the relations between present and imagined futures can be recalibrated using scenarios as 'hybrid realities.' Decker et al. (2017) investigate the potential for TA practitioners to help stakeholders 'productively imagine options for future desirable technological solutions' aligned with their needs, while Nielsen and Boenink (2020) study possibilities for the acknowledgement of patients as both stakeholders and active knowledge providers. Based on a multi-sector workshop, Jarmai and Vogel-Pöschl (2020) argue that meaningful stakeholder collaborations open up research and innovation processes to the needs of societal actors other than immediate beneficiaries. Focusing on 'narrative as a resource' for responsible governance, Macnaghten and Guivant (2020) examine why in one case a deliberative workshop corresponded to a shift from 'a top-down technocratic model to a more deliberative model' while a second one 'failed to gain political traction.'

Such empirical studies often combine multiple forms of engagement, such as expert-stakeholder collaborations to deepen stakeholder assessment (Decker et al. 2017) or to overcome entrenched power dynamics (Timmermans et al. 2020). They also often overlap with *Assessment*: in evaluating co-creative stakeholder workshops, Jansma, Dijkstra, and de Jong (2022) find that such engagements entail a trade-off between adding value to innovation and creating legitimacy, with a tension between deliberation that comes early in the innovation process and that focuses on 'the inclusion and anticipation of societal values.' By comparison, Reynolds, Kennedy, and Symons (2023) review scholarship advocating for public engagement and identify three main objectives: 'substantively improving decision-making, deontologically fulfilling widely-held norms, and politically redistributing power away from techno-scientific elites.'

Governance from within

Intervention-oriented scholarship also takes place within – or with an eye toward informing – various scientific, engineering, expert, industrial, organizational, and other sites of research and innovation performance, implementation, and governance. This area of study is home to several interventive approaches, including serious play (e.g., van der Meij, Broerse, and Kupper 2017), action-research (e.g., Valkenburg et al. 2020), applied ethics (e.g., Urquhart and Craigon 2021), sociotechnical design (e.g., Hess et al. 2021), engaged research (e.g., Olabisi et al. 2023), social labs (e.g., Marschalek et al. 2022), living labs (e.g., Campos and Marín-González 2023), and different forms of collaboration (e.g., Hernández et al. 2023) and co-creation (e.g., Felt et al. 2023).

Several of these studies combine engagement with such technoscientific practitioners and engagement with publics (e.g., Decker et al. 2017; Felt et al. 2023).

Collaborative and deliberative engagements combining *Intervention* and *Interpretation* take place across numerous empirical contexts, such as scientific and laboratory settings. For example, Balmer et al. (2016) draw from a wide variety of collaborative research settings to articulate rules of thumb meant to help embedded and engaged researchers cope with the everyday struggles of post-ELSI interdisciplinary collaborations; Lee et al. (2019) compare ethical reflection during normal research practices to a 'rare bird' that is seldom seen; and Aparicio (2021) suggests engaged scholars can make visible questions about the framing of problems in science and innovation. Similar studies within industrial settings include Flipse and van de Loo (2018), who adapt STIR to engage uncertainties during the early stages of industrial innovation management; Brand and Blok (2019) and Lubberink et al. (2019), who critically assess possibilities and pitfalls of deliberative engagement in companies; Lehoux et al. (2020), who develop an assessment tool for rendering more transparent the responsibility trade-offs entrepreneurs face in healthcare businesses; and Long et al. (2019), who assess the uptake of responsible innovation in sustainability-oriented start-ups. Two examples of policy-oriented interventions are Kuzma et al. (2018), who employ system thinking as a practice of collaborative policy design, and Smith et al. (2021), who reflect on their experience in developing a normative framework for a research funding program. Still other empirically-informed examinations operate across varied and various organizational and institutional settings (e.g., Sauer and Bonelli 2020; van de Poel et al. 2020).

Combining *Intervention* and *Assessment*, Fisher et al. (2015) compare collaborative integration approaches, distinguishing between those that work within local definitions of values to augment expert practices and decision-making and those that problematize existing practices and ask whether experts consequently adjust their values and behavior (e.g., De Jong, Kupper, and Broerse 2016). While some document learning, adjustments, and other forms of midstream modulation (e.g., Flipse and van de Loo 2018), analyses of collaborative engagement projects more often elaborate on similar struggles in assessing outcomes (e.g., Aicardi, Reinsborough, and Rose 2018; Lee et al. 2019; Pansera et al. 2020). Meanwhile, Mann and Chiapperino (2023) suggest 'articulating already existing forms of responsibility practices developed by experts themselves and analysing the ambivalent effects they engender,' which they conceptualize as 'critique from within.' Overall, the extent to which reflexive and practical effects can be observed and related to interventive activities, the challenges facing collaborative engagement (such as power asymmetries and vulnerabilities), and various methodological challenges (such as intervention is imposed from the outside or comes too late) continue to be topics of extensive discussion in recursively reflexive case studies (e.g., Balmer et al. 2016; Stahl et al. 2021).

Finally, studies combining *Intervention* and *Articulation* include Wender et al. (2014), who develop anticipatory life cycle assessment to help identify and sustainably address relevant uncertainties in research and development decision-making; Fisher et al. (2015), who offer a framework for tracing the effects of shifting positionality and normativity in collaborative research projects; Kiran, Oudshoorn, and Verbeek (2015), who develop ethical CTA to help actors go 'beyond checklists' and take soft impacts of telecare technologies into account; De Boer, Hoek, and Kudina (2018), who, considering 'normativity from 'within' human-technology relations,' argue that technological mediation

holds considerable potential to address emerging technologies but requires a transformation of current TA approaches; Felt, Fochler, and Sigl (2018), who present a card game method to empower researchers to appropriate responsible research practices and reflect on how institutional contexts interact with these practices; and Ryan et al. (2023), who develop a model to operationalize responsibility in start-ups, among others. These approaches to *Intervention* may articulate quality criteria and indicators for transdisciplinary approaches to responsible innovation (Wickson and Carew 2014), frameworks for incorporating activities and process requirements related to playfulness into reflective learning processes (van der Meij, Broerse, and Kupper 2017), practical frameworks to help make responsible innovation more tangible to scientists and engineers (Fraaije and Flipse 2019), conceptual insights for engaging collective improvisation as a form of responsible governance (Sauer and Bonelli 2020), and theoretical arguments for adapting STIR to innovation ecosystem contexts (Smolka and Böschen 2023).

Education, instruction, and pedagogy

Pedagogical interventions take place within diverse educational, training, and formative settings for professional and scientific actors and institutions, spanning formal classroom settings (Richter, Hale, and Archambault 2019) to informal events (e.g., Eggleson and Berry 2015), and, like other instances of *Intervention* overlap with at least one of the other three *styles*.

Sunderland et al. (2014) analyze a program that engaged engineering and philosophy graduate students in interdisciplinary ethics research, which Spruit (2014) describes as creating a safe zone for investigating ethical dimensions of engineering research practices. Based on a rich and comprehensive synthesis of responsible innovation frameworks and principles, Marschalek et al. (2017) relate an interactive reflection training approach that seeks to support mutual understandings of responsibility across different stakeholder groups and to implement these understandings in daily practices. Richter, Hale, and Archambault (2019) detail applications of a hybrid learning model they developed to incorporate normative principles into educational policies and practices as well as the use of innovation in university classrooms. Critical approaches such as those employed by Tomblin and Mogul (2020) seek to destabilize cultural norms of societal disengagement and connect pedagogical innovations with the politics of knowledge production with reflexive practices of learning. Deppeler and Aikens (2020) employ responsible innovation principles to analyze the design, construction, and use of new schools and to align educational agendas and practices with architectural practices and designs. Conley, Tabas, and York (2023) illustrate how Future Labs take a critical making approach to train science and engineering students in a wide range of reflexive, anticipatory, communication, and collaboration skills. Bardone, Burget, and Pedaste (2023) develop the RRI Map to integrate responsible innovation principles into the field of science education and identify activities teachers and learners can engage in for the sake of teaching science responsibly.

Breakdown and distribution of the styles

Coding each of the 304 articles according to its participation in each of the scholarly *styles* and their many combinations reveals their presence and durability as distinct approaches to studying responsible innovation. It also reveals their robust and relatively

Table 1. *JRI* articles engaging in single vs. multiple styles.

Style use	No. of articles	Percentage
Single	117	38%
Multiple	187	62%

proportionate distribution across the field of their possible interactions as seen in a Venn diagram of their intersecting spaces (Figure 1).

We find that *JRI* authors engage robustly with and within the various *styles*, in several respects: While nearly two out of five *JRI* articles operate more or less exclusively in a single one (38%), suggesting the sufficiency of those *styles* for advancing scholarly debates about responsible innovation, a majority (62%) combine multiple scholarly *styles* (Table 1). Additionally, while three of the four allow for both singular and multiple use, *Intervention* appears only in combination with one or more of the other three *styles*, a reminder that action in and of itself is not a viable form of scholarship (Table 2, Figure 1). Furthermore, the analytical distribution shows that the *styles* overlap with and support one another in multiple ways – both within the same article and across all articles collectively. For, except as noted for *Intervention*, which never appears by itself, *JRI* articles employ and combine the four scholarly *styles* in every analytically possible way (Figure 1).

Finally, the ratio between each *style's* single and multiple use as distributed across all articles shows less deviation than might be expected: *Assessment* is the most abundantly employed scholarly *style*, both among articles engaging in a single *style* ($n = 60$) and among articles engaging in multiple *styles* ($n = 182$); *Interpretation* is the second most abundant, also among both article groups (with 35 engaging in its single use and 159 in combination with other *styles*); and the two least abundant *styles*, *Articulation* ($n = 22$, $n = 125$) and *Intervention* ($n = 0$, $n = 91$), follow suit. This last finding suggests that, despite the rather uneven presence of each *style* relative to the whole, each one is similarly flexible and adaptable, and is distributed across the other three *styles* to a similar degree.

Conclusion

As this editorial review suggests, *JRI* has cultivated vital spaces for established, emerging, and combined forms of scholarship on the 'normative governance, practice, and assessment of knowledge-based innovation' (*JRI* Aims and Scope). These forms of scholarship can be categorized in distinctive, yet overlapping *styles*, which help us reflect upon both past accomplishments and future priorities of responsible innovation scholarly research directions and agendas.

Cumulative and interconnected

Wiarda et al. (2021) find that the scholarship on responsible innovation has 'matured into an increasingly cumulative and interconnected research trajectory following the

Table 2. *JRI* articles engaging in single styles.

Style	No. of articles	Percentage
Assessment	60	20%
Interpretation	35	11%
Articulation	22	7%
Intervention	0	0%

footsteps of similar, more mature research areas.' Our review suggests just how richly intricate and varied this interconnectedness is and provides a detailed – though minimally illustrated – glimpse of some of the many topical, thematic, and modal ways in which this accumulation of scholarly knowledge and understanding has played out in this journal. The well-defined presence of four distinct scholarly approaches to responsible innovation (Table 1), the fact that they overlap with one another in all but one of the analytically possible intersecting spaces that we examined (Figure 1), and the relatively proportionate distribution of articles across these intersecting spaces (ibid.) all point to the flexibility of the *styles* as well as to the willingness and ability of *JRI* authors to engage this flexibility in the process of developing an abundance of sustained topical areas of scholarly interest and debate. Viewed from a formal rather than substantive perspective, *JRI* articles not only cut across these four *styles*, many of them also navigate the tricky interstices in between them – including modernist dichotomies of theory/practice, observation/normativity, and distance/proximity regarding one's object of study. Such dichotomies are arguably always present beneath the surface of polished scientific endeavor, but they become less avoidable and more pronounced as scholarship reflexively takes on questions of social, moral, political, and ecological responsibility in the governance and practice of research and innovation, as these forward-looking articles do.

While we will continue to provide rigorously reviewed and refereed space for individual scholarly interests and agendas, we also wish to highlight three possible areas for *JRI* articles over the next 10 years to consider as they continue to build upon, contribute to, and critique RI/RRI/TA and related discourses sketched out above and beyond. We see these as cutting across macro-, meso-, and micro-scales of innovation and responsibility.[9]

Responsible innovation in the Anthropocene

The demarcation of our era as the *Anthropocene* (e.g., Wallenhorst and Wulf 2023) forcefully illustrates the immense responsibility of humankind at the planetary level. As an essential feature of the *Anthropocene*, knowledge-based innovation is inseparable from increasing interdependencies among climate change, biodiversity loss, natural resource depletion, digital and globalized financial markets, international value chains and logistics, cloud-based computing (much of which is beyond national regulation), new divisions of labor, and geopolitics, to name only a few relevant topics that have so far received limited attention in responsible innovation scholarship. Assessing, exploring, and debating what responsible innovation means at the global and planetary level is urgently needed. Building on existing responsible innovation scholarly knowledge, discourses, and practical experiences (see above), and given the wickedness of planetary problems, future submissions may wish to reflect on how responsible innovation could be made meaningful at the global level as well as how previously articulated frameworks for it are being adopted, adapted, transduced, and transcended within contexts of planetary governance and co-existence. Furthermore, future submissions may wish to investigate how various tools, methods, concepts, and approaches discussed within responsible innovation scholarship can play roles in helping to assess, inform, and leverage relevant policy initiatives as normative frameworks that help 'make responsibility work' in the face of existential threats. Relevant policy interests and initiatives in this area include the UN 2030 Agenda centered on Sustainable Development Goals (SDGs), European Parliament interest in the circular

economy and calls for 'convivial technologies,' and the US CHIPS and Science Act's significant mention of 'ethical and societal considerations.'

Responsible innovation in industry

Ten years ago, a general critique of responsible innovation scholarship pinpointed the lack of case studies as compared with more abundant attention to frameworks and other conceptual foundations. From our present vantage point, it appears that observational and engaged studies have kept pace with the articulation of frameworks and other constructs. Arguably, one reason for the increase in case studies is due to the rapidly emerging scholarly area of responsible innovation in industry and in the private sector (e.g., Flipse and van de Loo 2018; Brand and Blok 2019, Long et al. 2019, van de Poel et al. 2020; Lehoux et al. 2020; Ivanova et al. 2023; Li, Owen, and Shaw 2023). Encompassing a range of topics in business, management, and organizational theory, this work cuts across the four scholarly *styles* and makes important advancements to help move private sector research and innovation beyond dominant notions and practices of responsibility that have long been criticized for failing to inform – and to transform – core practices and governance mechanisms within industrial organizations. Scholars working in this area, however, must often tread a fine line as they seek to navigate often uneasy tensions between standard business models and commitments to corporate profit, on the one hand, and more socially, ethically, and ecologically informed notions of forward looking and fiduciary (Thompson 2018) responsibility, on the other. We encourage theoretical, empirical, and experimental efforts to better understand how opportunities for engaging these tensions and ambivalences within commercial firms and other competitive environments (Garst et al. 2022) can be identified, opened up, and productively sustained. We also invite the development of new tools, theories, and case studies aimed at probing and illuminating them. The rapid and widespread embrace of responsible AI, ethical AI, trustworthy AI, and the like underscores the need to problematize and enrichen more instrumental goals of public acceptance and legitimation with more robust, sustainable, and reflexive forms of responsible innovation in industry.

Making space for intervention

JRI has cultivated unique and vital scholarly space for intervention-oriented research operating at the intersection of socioethical and technoscientific domains. As this editorial review shows, for *Intervention* to function as a scholarly approach to knowledge production, it must go beyond demonstrating immediate and practical utility for sponsors, collaborators, clients, or participants. Instead – or rather, in addition – it must be married with *Articulation, Interpretation,* and/or *Assessment.* In this way, the *JRI* community ensures that situated experiments, co-creation exercises, public deliberations, and other collaborative inquiries are always complemented by reflexive engagement with their inceptions, processes, and outcomes. This is crucial because unlike in the clinical field, where interventions are either considered as medical treatments following best practices or as clinical procedures strictly executed according to a pre-defined research protocol, interventions in responsible innovation tend to emerge from within collaborative practices. *Intervention* is thus not launched from an outside position to achieve

unidirectional effects, but instead emerges from within 'hybrid spaces, in which many agents constantly negotiate and influence each other' (Zuiderent-Jerak and Bruun Jensen 2007).

Intervention-oriented studies offer opportunities for work done in the other scholarly *styles* to continually integrate lessons learned from collaborations and engagements with actors in the field, just as the other three *styles* help keep it vital and accountable. *Intervention* supplemented by *Articulation* helps unpack epistemological and ontological underpinnings of responsible innovation practices. In interdisciplinary collaborations, realist, constructivist, pragmatist, and other conceptions of research objects and practices encounter one another. By learning to articulate one's own theoretical stance within a range of situated contexts, opportunities to draw connections across ontological and epistemological differences – in the sense of 'doing difference together' (Verran 2013) – can emerge. Combined with *Interpretation*, it allows for an exploration of politics, uncertainties, and emotions, which often disappear from scholarly accounts in more established research areas in the social sciences and humanities. *JRI* provides a platform where research processes can be opened up to scrutinize power differentials, intuitive and improvised methodological choices, and unruly affects. Exploring the 'messiness' of intervention as an exercise in knowledge production enables transparent and reflexive engagement with responsible innovation practices (Smolka, Fisher, and Hausstein 2020). Finally, insofar as intervention is a complex and partly uncontrollable process, *Assessment* helps engaged researchers understand and account for the indeterminate theoretical, practical, and political dimensions of this process. *JRI* invites scholars to trace the effects of their shifting positionality and normativity in research projects (e.g., Fisher et al. 2015), taking seriously that they often take on the role of 'ambivalent actors' (Shanley 2022) who both resist and succumb to dominant innovation imperatives. To critically interrogate the possibilities for such ambivalent actors to provoke transformative change, *Intervention* needs to be complemented by iterative and process-oriented monitoring and evaluation (cf. Klaassen et al. 2020).

Intervention also helps show how scholars of responsible innovation are often on the front lines, doing applied, experimental research within the field, ultimately to learn from and contribute to scholarly knowledge generated in combination with the other *styles*. In this respect, *JRI* has sought to make a special place for junior scholars and early career researchers (cf. Shanley et al. 2022) who often operate on these front lines, while more senior scholars set the foundations of the field (e.g., Owen, von Schomberg, and Macnaghten 2021).

Looking forward

This editorial review offers an overview of the scholarly discourses related to responsible innovation, as published in *JRI*. This overview can be used as a map to help orient both regular contributors to these discourses as well as newcomers to the field to the rich variety of complementary and adjacent work that may be relevant to their own inquiries. As editors, we intend to continue to cultivate timely, coherent, and evolving conversations that build on existing and ongoing scholarly work, as well as to encourage provocations, including those that disrupt the categories we have employed herein. The continuing, if not accelerated, emergence of disruptive innovations in the midst of

multiple ongoing crises underscores the need for significant change in how modern industrialized societies imagine, organize, and govern innovation. At the same time, this need can result in the (misleading) conclusion that scholars, policymakers, industrial leaders, and scientific administrators need a stable blueprint to 'fix' the uncertain, complex, and ambiguous societal dimensions of innovation. But as this review suggest, context, process, learning, and continuing assessment are key. In this light, what is needed is not so much an endorsement of any central concept, principle, or method, but the commitment to continued learning, multiple perspectives, and productive collaboration. Our editorial review demonstrates that the *JRI* community has embodied these commitments in its own work by showing itself to be collectively both interested in and adept at employing the flexibility and adaptability of multiple distinct approaches to studiously engaging what responsible innovation does, could, and should mean across a multiplicity of sites, scales, and contexts. We look forward to what this community develops as it continues to build on the scholarly approaches and topical areas described herein.

Notes

1. The year 2014 was an important one for responsible innovation both in policy terms and as an intellectual endeavor, as the initiation of this journal reflects. Responsible Innovation (RI) and its loose cognate Responsible Research and Innovation (RRI) were emerging areas of policy interest, particularly at the European Commission and within the UK's research councils (Von Schomberg 2011; Owen, von Schomberg, and Macnaghten 2021), and both had deeper roots in the US National Nanotechnology Initiative's emphasis on responsible development (Fisher 2019a) and in the related approaches – developed in Science and Technology Studies (STS) and beyond – including constructive technology assessment (Rip and te Kulve 2008) and anticipatory governance (Barben et al. 2008). The academic community continued to build on these, and in 2013 a framework for RI was published (Stilgoe et al. 2013). Meanwhile, in 2014 the 'Rome Declaration' on RRI in Europe was published by the European Commission, providing significant funding for the emerging field.
2. In addition to being based in a wide range of traditional disciplines, such as Anthropology, Philosophy, Political Science, and Sociology, *JRI* authors also draw from numerous interdisciplinary fields and sub-fields, including but not limited to Applied Ethics, Cultural Studies, Engineering Ethics, Feminist Studies, Futures Studies, Indigenous Studies, Innovation Studies, Management Studies, Philosophy of Science, Philosophy of Technology, Policy Studies, STS, Sustainability Science, and Transition Studies.
3. The total number of articles coded and analyzed for this review is 304. This number excludes a few dozen more Editorials, Guest Editorial Introductions, and Book Reviews, some of which nevertheless feature in the editorial review's narrative.
4. For instance, these have generally employed the lower-case terminology 'responsible innovation.'
5. This (much abbreviated) list is meant to illustrate the rich diversity of conceptions and schools of thought oriented at the normative governance, practice, and assessment of knowledge-based innovation found in *JRI*. It is neither an exhaustive list of such instances, nor does it include any of the large number of conceptual dimensions (e.g. accountability, anticipation, inclusion, public values, reflexivity) or theoretical approaches and idioms (e.g., Civic Epistemology, Coproduction, Institutional Analysis and Development, Midstream Modulation, Social Construction of Technology, Technological Mediation) that *JRI* authors make use of.
6. Inductive coding of 304 published articles (including Research Articles, Perspectives, Discussion Papers, and Responses) was initially performed by Fisher, Smolka, and Nelson; Fisher then re-coded all articles deductively for consistency. Although we did not include

Editorial Introductions and Guest Editorial Introductions in the coding exercise, we do reference some of these in our narrative presentation of the overall editorial review.

7. We regret that we could not include mention and discussion of all published articles. In-depth discussions of most articles published in *JRI* can be found in the numerous Editorial Introductions and Guest Editorial Introductions that have appeared in most issues of the journal's first ten years.

8. That said, and as we show later (see Figure 1), all styles can and do interact with the others. Thus, *Articulation* and *interpretation* often co-exist in *JRI* publications, for example when they use empirical material to develop or assess an analytical framework (e.g., Glerup and Horst 2014; Politi and Grinbaum 2020; Shanley 2021).

9. Additional suggestions for research directions and agendas can be found in the Guest Editorial Introductions of recent *JRI* special issues (e.g., Doezema et al. 2019; van Oudheusden and Shelley-Egan 2021).

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